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Abstract

IN-CORE INSTRUMENT DEVELOPMENT IN THE HBWR PROGRAMME

by

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The development of fuel channel flow and void measuring turbines, dynamic void gauges, heat flux measurement and boiling channel power measuring devices was initiated to support the experimental dynamics research programme at HBWR by permitting continuous dynamic measurement and comparison of in-core parameters during perturbation experiments.
With successful long term performance of this type of device, in-pile, the instrument development programme was diverted towards in-core protection and measuring devices for high powered test fuel elements operating at real heat transfer limits. Devices in this category which have been or are being evaluated with test fuel channels are the burnout detector, the gamma thermometer, central oxide thermocouples and instability monitoring.
In new dynamics investigations at HBWR in-pile channel flow perturbation devices will be tested in association with short-time-constant instrumented tubular metallic fuel assemblies.

In the process of testing past instrumented fuel assemblies, natural circulation steady-state hydraulics measurements have been made parametric in pressure, channel power, subcooling and axial flux shape and differences from both calculations and prediction from electrical loop data have been observed.

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Abstract

DYNAMICS OF BOILING HEAVY WATER REACTORS BASED ON HBWR RESEARCH PROGRAMME

by

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In the period from 1960 to 1963 extensive reactor statics and dynamics investigations have been conducted at HBWR to develop models describing the behaviour of natural circulation boiling D_2O reactors. The two fuel charges used in these investigations are: a low-power density aluminium clad, natural metallic uranium fuel charge and a high-power density, Zircaloy clad, 1.5% enriched uranium oxide charge.

The necessary equipment and experimental techniques for obtaining reactor transfer functions were developed and successfully employed in the dynamics programme performed with the metallic fuel charge. In this programme the responses in integral parameters such as power, steam flow, pressure and steam and water temperatures were measured during perturbation experiments. The number of parameters entering the dynamics models are, however, so numerous and the measured parameters so few that by empirical adjustment the models could be constrained to reproduce the experimental results over the ranges of test conditions. It was found difficult through this macroscopic approach to develop models that could be confidently extrapolated to other reactor designs.

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It was early recognized that the direct measurement of the microscopic parameters such as: channel steam void, fuel and channel coolant temperatures, and local coolant velocities, in addition to the integral parameters, was the most promising approach to the development of models that would permit extrapolations. This recognition, together with an absence of proved instruments for such measurements, led to the development of in-core instruments for the dynamic programme with the oxide fuel charge. The in-core instrument development programme is described in another paper to this conference.

To permit simultaneous analysis of the time behaviour of a large number of in-core signals in the dynamic programme with the oxide fuel charge, an extensive system for automatic data reduction was developed. The system employs a two channel transfer function analyser, a special analogue computer for noise correlation studies, high speed visual recording equipment, a 60 amplifier analogue computer for reducing instrument signals to meaningful dynamic parameters before analysis, an analogue-to-digital converter and a small, but fast, digital computer.

From load perturbation experiments carried out with the low power density metallic fuel charge, it was observed that the nuclear power smoothly followed load changes without unpleasant transients which are characteristic for light water boiling reactors with large (negative) void reactivity coefficients. A quite different behaviour was, however, observed with the oxide fuel charge. When the reactor was subjected to an increase in steam load demand with this fuel charge (operating at power levels above 10 MW), a violent nuclear power transient was observed. This effect turned out to be due to moderator flashing as a result of the decrease in vessel pressure accompanying the increase in steam load demand. A long period instability was actually observed at power levels above 15 MW. From an analysis of this instability, it could be concluded that (1) the flashing instability is of a frequency low enough to be controlled with nuclear feedback control, (2) light water reactors with high coolant void reactivity worth and with down-comer in the reflector where the void reactivity worth is small will

normally not encounter this instability, (3) the instability can be avoided by subcooling of the moderator (e.g. as in the Swedish Marviken reactor).

From the dynamics investigations carried out, it can be concluded that the models previously developed for natural circulation light water boiling reactor stability predictions are not applicable to a natural circulation heavy water boiling reactor. While in the light water boiling reactor dynamic model the entire core is usually considered as a single upcoming boiling channel, with the downcomer in the reflector, there is only a very weak hydraulic coupling between the various channels of a heavy water boiling reactor. This difference between light and heavy water boiling reactors makes it possible to achieve higher coolant power densities stably in D_2O reactors than in H_2O reactors.

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Abstract

RADIOMETRIC ASSAY OF TRACER AMOUNTS OF PLUTONIUM IN DEPLETED URANIUM

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After careful calibration of the ion chamber, with natural uranium, a number of electrodeposited mixtures of Pu-U from depleted uranium were measured for alphas.

The mixtures, chemically dissolved from their stainless steel plates, were stripped of their Pu content and the latter newly assayed after a second electrodeposition. The results are discussed.

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Abstract

Two radioactive sources used in an unconventional way.

A. Radiography with Specious Sources of Radioactive Liquids or Gases

T. Cless-Bernert and K. Duftschmid

B. A Megarad β-Source

T. Cless-Bernert and N. Getoff

ABSTRACT A.

In cases where conventional radiographic methods are not applicable- for instance for inspection of blocks of narrow tubes in side of steam vessels - a new method applying radioactive liquids or gases is described. Using very soft β-emitters radiographs of sufficient quality of weldings, corrosion defects and deposits inside the tubes can be ob sined. The method has been used in practice to examine the rate of corrosion in steam vessels of a sugar plant.

ABSTRACT B.

For sterilization or radiation treatment of liquide and gases or other suitable goods a tube-shaped Sr-90 source has been constructed.

By making use of this geometrical arrangement and of the much higher density of ionisation of β-rays compared to γ-rays high irradiation doses may be obtained by relatively small amounts of activity. Since also shielding problems are much easier to be solved with β-sources even if there is a high percentage of bremsstrahlung, this type of source could prove to be of high economical value.

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Abstract

THE INCORPORATION OF NUCLEAR ENERGY TO THE SPANISH POWER NETWORK

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Dirección General de la Energía. Madrid

Spain is subjected to a fast rate of increase in electrical energy consumption, which has doubled in the last seven years. The hydroelectrical resources, today representing 75% of the total production, have progressively been depleted. Domestic fossil fuels are costly and their production is insufficient to cover the needs of electrical energy production through thermal stations. Imported fuel is needed, generally crude oil, to fill in the gap.

With this situation as a basis, the incorporation of nuclear stations in the Spanish electrical system has been studied, taking into account, especially, the competition with thermal stations which burn imported fossil fuels. In this study the structure of the Spanish electrical network is considered, especially with reference to the size of the nuclear stations and their utilization factor.

The program of installation of nuclear power plants in Spain is indicated based on the applications submitted by the utilities and the general lines established by the Government. The necessary investment and the possible participation of Spanish industry are also analyzed.

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Abstract

FUNDAMENTAL METALLURGICAL STUDIES FOR THE IMPROVEMENT OF METALLIC URANIUM FUEL ELEMENTS.

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This paper reviews the results of research work conducted by SNAM-LRSR into the metallurgy of metallic uranium fuel elements, and covers the study of uranium - rich niobium alloys in the range 0.2-7.2 wt % Nb and the intermetallic diffusion between uranium - titanium and titanium - Magnox AL 80 couples.

The use of uranium - rich molybdenum alloys in power reactor fuel elements stimulated research into the metallurgically similar uranium - rich niobium alloys, which have lower capture cross-sections. The analogy between these two types of alloy was examined by studying the kinetics and mechanisms of transformations occurring during interrupted quenching and continuous cooling from the γ and the $\beta + \gamma_1$ fields. The characteristics of the metastable phases obtained by water quenching from the γ phase and the Ms temperature vs. composition curves of the alloys have also been compared. Hardness and structural changes taking place during the ageing of the metastable α'_a and α''_b phases in uranium-niobium alloys are reported. With regard to irradiation experiments attention has been paid to the different structures obtainable in uranium-niobium alloys by various heat treatments and to the stability of these structures at reactor temperatures.

With a view to improving fuel element behaviour regarding heat

transfer and the mechanical properties of the can, the behaviour of titanium as a bonding element between uranium and Magnox AL80 has been studied using commercial purity materials. Results of metallographic examination and electron probe micro-analysis of the intermetallic diffusion occurring between couples of uranium-titanium and titanium-Magnox AL80 are reported. Uranium-titanium diffusion was studied in a single phase field and in a polyphase field of the equilibrium diagram. The results obtained indicate that the carbon present in uranium, plays an important role during the diffusion. In fact there is a tendency for the formation of agglomerates of titanium carbide in such a manner as to hinder the diffusion of titanium in uranium. The volume diffusion in these couples was accompanied by an intergranular component of diffusion, while anomalous grain growth occurred in the titanium probably as a result of stresses operating during the diffusion treatment. By means of a special electron probe micro-analysis technique it was possible to establish the existence of diffusion of titanium in Magnox AL80 and also evaluate the solid solubility limit.

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Abstract

LATINA NUCLEAR POWER STATION: COMMISSIONING AND FIRST OPERATIONAL EXPERIENCE

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ENEL, IMPRESA SIMEA Latina, Italia
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The paper describes the main tests carried out during reactor commissioning and the subsequent operational measurements and analyses relevant to the safety and efficiency of the Latina reactor.

The commissioning tests described are:

1. First loading to criticality and small pile experiments.
2. Loading to full size and built-in reactivity measurement.
3. Absorber calibrations and associated experiments.
4. Cold control rod calibrations and shut-down capacity evaluations.
5. Gas setting.
6. Hot built-in reactivity measurements and temperature effect on control rod efficiency.

Wherever possible, the experimental results were compared with the available theoretical predictions made by the design divisions.

A peculiar aspect in that the Latina power station has ever been specifically designed to give flexible performance over the power range.

The paper includes a brief description of how the overall power control system has been arranged to achieve this, and gives operational results.

The unusual occurrences of the first operating period are then described, among which procedure which was followed for recovering a control rod that dropped into the core due to the failure of the holding chain.

During this same period, a number of experiments were performed and some procedures or new techniques were developed in order to link commissioning and routine operation and complete the results obtained during the test period.

The main feature of these procedures is that they affect directly the efficiency and safety of the plant operation.

They can be summarized as follows:

(a) Absorber cycling, with contemporary local reactivity compensation by locally trimming control rod pattern. This eliminates or reduces to a large extent local temperature peaks, allowing better average gas outlet temperatures during absorber movements.

(b) Identification of the burst fuel element among the eight of a suspect channel, on removal from the channel. This makes possible a saving in fuel and time in bottling and transport expenses as well as in laboratory examinations.

(c) Operational calibration of the control rods by the xenon technique.

(d) Assessment of the standard deviation of the readings of the reactor thermocouples by means of experiments on isothermal reactor.

(e) Experiments relative to the flux disturbances subsequent to irregular movements of individual control rods, either scheduled or accidental, and determination of safe procedures.

(f) Preparation and finalization of new measurement methods with operational purposes, such as temperature coefficients.

A general assessment of the commissioning and initial operation at power is made in the conclusion.

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Abstract

THE POWER OUTLOOK IN AUSTRALIA

by the

Australian Atomic Energy Commission

and the

Department of National Development.

Existing electricity generating and transmission arrangements are described and demand and demand growth, present and future (to 1975), are summarised.

Fuel resources, problems of particular States, current trends in collaboration between states for electricity generation and supply purposes and the outlook for the use of black and brown coal, oil, hydro, natural gas, nuclear and tidal power are mentioned.

It is suggested that, in the larger electrical systems in Australia utilizing relatively cheap and abundant sources of black and brown coal, there is little likelihood of nuclear power being introduced within the period under review.

In some of the smaller systems, in particular South Australia, indigenous fuel is less abundant or wholly committed, and fuel must be imported. In these circumstances nuclear power could be competitive. However, these systems are not yet sufficiently developed - individual system demand being below 500 MW - to enable nuclear units in the larger, less costly range to be introduced immediately. Nevertheless, considering current trends in nuclear power developments and costs, it is possible that nuclear units of the order of 200 MW capacity could be introduced within the period under review.

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Abstract

Basic heat transfer and hydrodynamics studies in two-phase flow.

M. Silvestri, N. Adorni, S. Bertoletti, I. Casagrande, L. Cravarolo, G.P. Gaspari, A. Hassid, C. Lombardi, E. Pedrocchi, G. Peterlongo.

A general survey is presented of the experimental work performed at CISE in the field of heat transfer and hydrodynamics of two-phase flow in forced convection. The main results are indicated and some correlations of the experimental data are given.

The main items are the following:

- Phase and velocity distribution.
- Pressure drop.
- Liquid volume fraction.
- Heat transfer.
- Heat transfer crisis.

The experiments were performed with upward flow in vertical conduits, and the annular-dispersed flow regime was mostly investigated.

Heat transfer data were collected with steam-water mixtures at high pressure (50 ÷ 90 kg/cm^2).

Most data on phase and velocity distribution, as well as on liquid volume fraction, were instead collected with two-component mixtures in adiabatic conditions at room temperature (pressure up to 22 kg/cm^2); however a limited number of experiments were carried out with heat transfer.

Pressure drop measurements were performed in all the experimental conditions

cited above, with and without heat transfer.

Round tubes were used for most experiments; however, more complicated geometries, such as annuli and clusters, were also investigated to some extent.

The influence of the hydrodynamic conditions at the inlet of the conduit and of the axial power distribution was also studied.

The experimental conditions with two-component mixtures were as follows:

Gas phase:	argon, nitrogen	Specific mass flowrate:		30 ÷ 300 g/cm^{2}s
Liquid phase:	water, ethyl alcohol	Quality:		0 ÷ I
Temperature:	I6 ÷ 40 °C	Round tubes	Diameter:	I.5 ÷ 2.5 cm
Pressure:	up to 22 kg/cm^2		Length:	I20 ÷ 350 cm

With steam-water mixtures, the explored range was:

Pressure:	50 ÷ 90 kg/cm^2	Round tubes	Diameter:	0.5÷2.5 cm
Specific mass flowrate:	I00 ÷ 400 g/cm^{2}s		Heated length:	2÷400 cm
Inlet quality:	-0.5 ÷ I			
Outlet quality:	above zero			

This work was performed under contracts with the European Atomic Energy Community (Euratom).

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Abstract

ADVANCES IN RADIOACTIVE WASTE MANAGEMENT TECHNOLOGY - ITS EFFECT ON THE FUTURE NUCLEAR POWER INDUSTRY

Walter G. Belter, U.S. Atomic Energy Commission

As the nuclear energy industry continues to grow, the problems of radioactive waste management can be broadly characterized as 1) the disposal or concentration of large volume, low-activity waste, and 2) the long-term or permanent storage or disposal of concentrated, high-level waste. Controlled environmental discharges of low-activity wastes have become more limited, primarily because of an expanding industry, but also due to the adoption of more stringent radiation protection guides.

These considerations have served as a basis for the U.S. waste management research and development program to develop improved and more efficient methods for the treatment and concentration of large volume, low-activity waste and for the ultimate disposal of these waste concentrates. New developments in synthetic ion-exchange, foam separation, and hydrofracturing, are discussed as potential future methods for the handling of low and intermediate level waste.

The inherent restrictions of tank storage for high activity waste, such as potential leakage and necessity of liquid-waste transfer for periods of hundreds of years, has resulted in an extensive "conversion-to-solids" research and development effort in the U.S. Pilot plant results on various calcination and fixation techniques, such as fluidized beds, heated pots, and radiant heated spray columns, are discussed. The addition of glass-forming materials to high activity waste for the purpose of providing a more stable final product is also being investigated. The proposed long-range waste management program at the Hanford production facility, with its particular site requirements, is briefly described. The effects of fission product removal for beneficial use is discussed as it relates to long-term waste management operations.

The investigation of specific geologic formations, such as salt structures and impermeable crystalline rock for ultimate storage or disposal of calcined solids

or certain types of liquid waste, is described. Plans for a proposed field experiment in salt with full-scale radioactivity are discussed.

Engineering evaluation studies, in connection with waste management operations in a future nuclear power economy, are summarized. The hazards and economics of various methods for handling, storage and/or ultimate disposal of high and low level liquid and solid wastes are being investigated. High level waste treatment and permanent storage costs for the nuclear power future have been estimated at approximately one percent of the total fuel cycle cost and less than one percent of the cost of nuclear power in a 4 mill/Kwh economy. Based on a continued successful field demonstration and testing program with high-activity waste, it is firmly believed that waste management operations will not provide any deterrent to the development and growth of the nuclear power industry.

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Abstract

U.S. OPERATIONAL EXPERIENCE IN RADIOACTIVE WASTE MANAGEMENT (1958-1963)

Walter G. Belter, U.S. Atomic Energy Commission

Although the nuclear energy industry in the United States is relatively still in its infancy, significant strides have been made during the past six years in the radioactive waste management field to further reduce the volumes and quantities of radioactive material being discharged to our environment. The initial operation of central station nuclear power reactors during this period has resulted in waste quantities amounting to only a few per cent of original design estimates. Power reactor waste management systems have performed with no major operating difficulties and radioactivity concentrations in plant effluents have ranged between 1-3 per cent of internationally accepted radiation protection standards.

Operating experience and data from waste management systems at United States atomic energy facilities such as national laboratories, production sites, reactor testing facilities, and nuclear power reactor installations, are summarized. The efficiency of various treatment systems for large-volume low-activity waste from these operations is evaluated. Recent experience on tank storage of smaller-volume, high-activity waste is briefly discussed, and new management techniques for reducing future tank storage requirements are described.

Ground disposal experience and practice in the United States, which is utilized for certain types of solid and liquid waste effluents, are discussed. Industrial interest in providing waste disposal services for large volumes of solid, low-hazard potential waste continues to increase in the United States. Land burial and sea disposal operations during the past six years are discussed and the recent opening of commercial land burial facilities is noted.

Limited cost data on radioactive waste management systems in the U.S. are presented. Capital costs for water-type power reactors range between 3 to 5 per cent of total plant costs; operating and maintenance costs for waste handling have ranged between 5 and 10 per cent of over-all plant operation and maintenance costs. On the basis of operating cost data and experience at large U.S. nuclear research laboratories and production facilities, it is firmly believed that waste management operations will not be a limiting factor in the growth and development of the U.S. atomic energy industry.

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Abstract

HEALTH PROBLEMS RAISED BY THE ELIMINATION OF RADIOACTIVE WASTES AND NUCLEAR ACCIDENTS.

Commissariat à l'Energie Atomique

The rapid development of nuclear energy demands an urgent solution to the health problems arising from the discharge into the environment of radioactive residues produced by nuclear installations.

To be able to evaluate the risks run by the population and to fix tolerance limits for waste discharge, it is necessary to possess an exact knowledge of the course taken by the radioelements discharged, from their source until they reach man. The incorporation of radioelements in food cycles is the first risk to take into consideration. The factors involved in all stages of this transmission must be foreseen, whether they concern physical or biological media, because of their continuity and their interdependence.

Finally, socio-economic and dietetic data must be collected in order that the riskes and tolerance levels estimated are based on concrete and experimental rather than theoretical knowledge.

The risk of nuclear accidents in the atomic industry, although very improbable, must be taken into consideration because of the seriousness of their consequences.

The health problems arise in the field of professional hygiene on the one hand and in that of public hygiene on the other.

In the first field the risk is two-fold and involves irradiation and contamination. The public sphere is reduced essentially

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to the risk of contamination by radioactive substances accidentally released in the surrounding medium.

The health studies to be conducted in this field therefore include research not only on irradiation or contamination therapeutics but also on the transfer of radioelements from the accident site to man, mainly through food cycles, in their physical and in their biological components. Studies of this kind form the basis of decisions in the health field which would have to be taken in the case of an accident.